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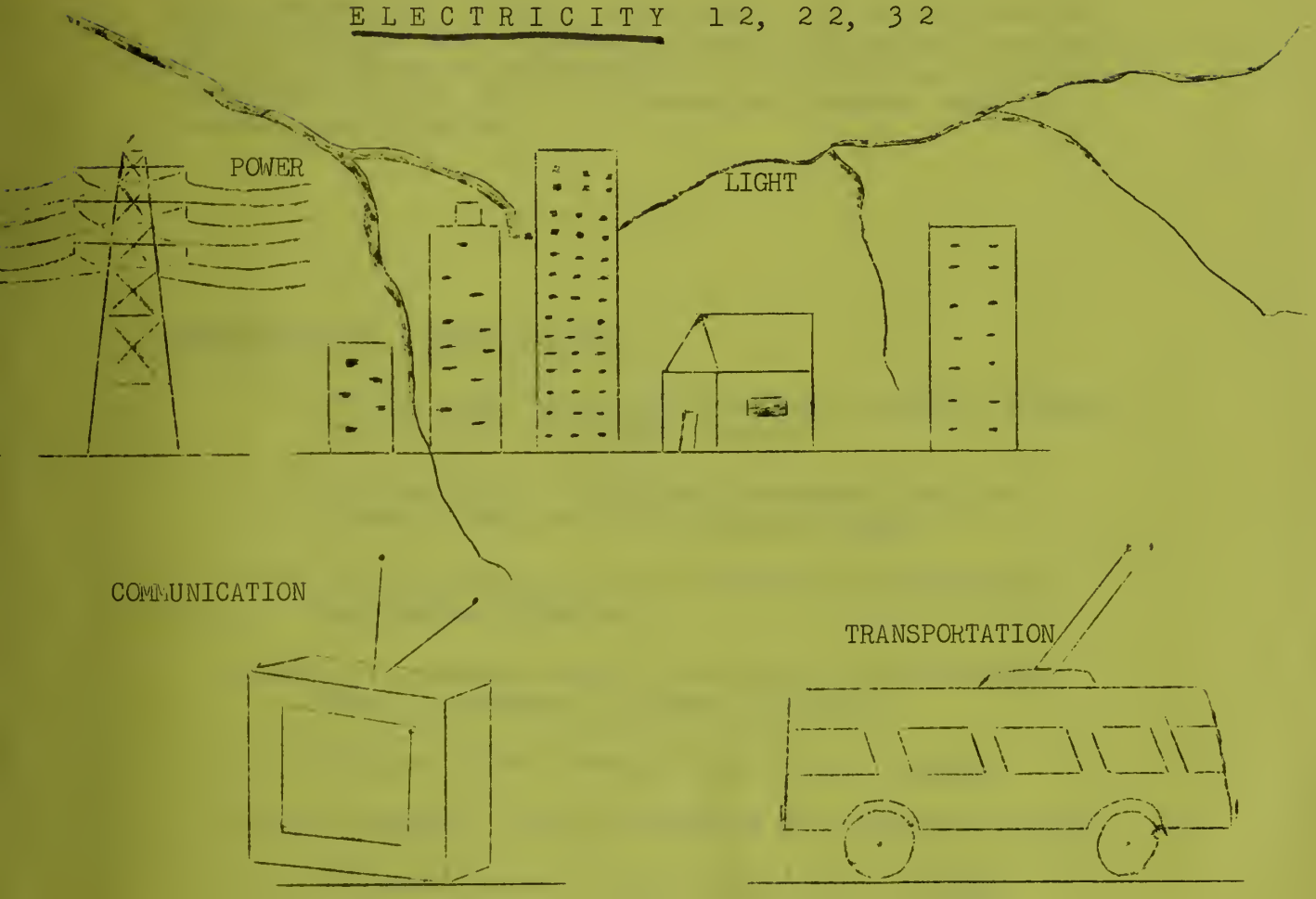
ELECTRICITY 12, 22, 32



DEPARTMENT OF EDUCATION
EDMONTON, ALBERTA

June, 1969

CURRICULUM GUIDE

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ACKNOWLEDGEMENT

The Department of Education acknowledges with appreciation the contributions of the following members of the Ad Hoc Subcommittee on Electricity to the preparation of this Curriculum Guide for Electricity 12, 22, 32. The Subcommittee operated under the Secondary School Board.

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NOTE: This Curriculum Guide is a service publication only. The information is prescriptive only insofar as the content of the Guide duplicates that contained in the Program of Studies for Senior High Schools of Alberta. The Curriculum Guide contains as well as content, methods for developing the concepts, suggestions for the use of teaching aids, and lists of additional reference material.

TABLE OF CONTENTS

		Page
1.	Foreward	3
2.	General Objectives	4
3.	General Information	4
4.	Electricity 12	6
	Objectives	6
	Texts	6
	References	6
5.	Instructions in use of Outline	7
6.	Course Outline for Electricity 12	8
7.	Electricity 22	11
	Texts	11
	References	11
8.	General Electrical Theory	13
9.	Shop Activities and Related Theory	17
10.	General Trade Skills and Knowledge	19
11.	Interim Wiring Practices	21
12.	Electricity 32	25
13.	General Electrical Theory	27
14.	Experiments, Shop Activities, and Related Theory	29
15.	Code Reference for Laboratory Manuals	30

FOREWORD

Man has had experience with electricity ever since he first appeared on this earth. He experienced it in lightning, in the northern lights, in combing his hair and stroking a cat. As an essential part of the life process, electricity is present in the human body. Man experienced electrical phenomena for centuries before he was able to recognize it as a force which could be harnessed and put to use.

Today we live in the electrical age. Electrical and electronic technology has moved ahead by leaps and bounds, far beyond our wildest dreams of a generation ago. Our knowledge increases so rapidly that machines have become outdated almost before they have left the drawing board. On the following pages the sequence of courses outlined are designed to provide the essential fundamentals for students who wish to pursue the study of electricity and find their life's work in this rapidly growing field.

GENERAL OBJECTIVES

1. To impart to the student a knowledge of the role that electricity and electronics play in industry today, and the opportunities that exist in this rapidly expanding field.

2. To equip the student with sufficient skill and knowledge such that he will be highly employable in the electrical field.

3. To provide the student with sufficient background in this area such that on entering the apprenticeship program he will be able to advance at an accelerated rate on the basis of his proven ability on the job.

4. To prepare the student to a degree of competency acceptable to the Institutes of Technology, sufficient for entry into the second year of the Electrical Technology program.

GENERAL INFORMATION

1. Course Credit Values

   Electricity 12 - 5 credits
   Electricity 22 - 15 credits
   Electricity 32 - 15 or 20 credits

   NOTE: Llectricity 12 is also the prerequisite for Electronics 22.

2. Safety Program

   Every shop must have an effective safety program. In the electrical shop, particular attention must be given to the safety measures required in the industry: adequate guards, cleanliness of shop and personnel maintained at a high standard, students properly clothed for their work, etc. The shop organization must be such as to ensure stressing this very important phase of the shop program.

   A good safety program features the following devices: regular, consistent and thorough instruction, constant vigilance and checking by the instructor, safety posters, student safety committee, adequate first aid equipment, instructor trained and up to date in first aid methods, dynamic color painting of machines and equipment, adequate working space about machines, safety lines on floor around machines, routine report on accidents however minor, machines and tools in approved working condition, a safety-conscious group of students and instructors.

3. Instructor's Records

The instructor should keep accurate records of:

a. student enrolment and attendance
b. student accounts
c. student work activity
d. theory covered
e. tests given
f. student achievement
g. up-to-date inventory of all equipment

4. Student's Records

Instructors should ensure that students develop and maintain a neat and accurate record of:

a. theory that is given
b. daily shop activities (time cards)

5. Enrolment

The maximum enrolment recommended for Electricity 12 is 20 students. Electricity 22 and 32 maximums are 15 students.

6. Guidance and Vocational Information

Instructors must assume responsibility in their own trade area to ensure that students and school guidance officials are aware of the local situation. It is essential that instructors be active, interested and informed regarding the opportunities in their field.

NOTE: In order to permit students from an academic Grade X program to crossover to the vocational program at the Grade XI level, schools may combine the "12" and "22" courses into one course for a total of twenty credits. Where these courses are combined, it is recommended that students purchase the Grade XI text only.

It should be clearly understood that success in the fields of electricity and electronics is largely dependent upon the student's ability in mathematics and science. Students possessing a 'C' standing in these subjects generally should not be encouraged to register in these courses.

Whereas the Electricity 12 course is an exploratory course open to all Grade X students, Electricity 22 and 32 and Electronics 22 and 32 are definitely vocational and only those students who have displayed ability and aptitude for the program should be encouraged to continue. It is not in the best interests of the student to permit him to continue in a program which demands a large portion

of his school time and in which the instructor and/or the guidance counsellor feels that he has little chance of success.

OBJECTIVES FOR ELECTRICITY 12

1. To provide exploratory experiences in the fields of electricity and electronics.
2. To acquaint students with the opportunities for employment in the electrical and electronics fields.
3. To provide the necessary background for Electricity 22 and Electronics 22.

TEXT

INTERMEDIATE ELECTRICITY, 1965 ed.	Frank J. Long	General Publishing Co.

In addition students must purchase the following Laboratory Experiment Manual:

BASIC ELECTRICITY (3rd edition)	Paul B. Zbar	McGraw-Hill

REFERENCE BOOKS

The following reference books should be in the library:

LABORATORY EXPERIMENTS, DIRECT CURRENT FUNDAMENTALS	John R. Duff	Delmar
BASIC ELECTRONICS	Bernard Grob	McGraw-Hill
BASIC ELECTRICITY - DIRECT CURRENT FUNDAMENTALS	Orla E. Loper	Delmar
INDUSTRIAL ELECTRICITY VOLUME I, DIRECT CURRENT (3rd edition)	Chester L. Dawes	McGraw-Hill
BASIC ELECTRICITY - Part I Part II	Van Valkenburgh	Technical Press
ELECTRIC CIRCUITS AND MACHINES (4th edition)	EUGENE LISTER	McGraw-Hill
INTRODUCTION TO ELECTRIC CIRCUITS	Herbert Jackson	Prentice-Hall

References Cont'd

CANADIAN ELECTRICAL CODE (latest edition)		Electrical Protection Branch, Dept. of Labour
EXPERIMENTAL ELECTRICITY	Rahn-Magnuson-Dooley	McGraw-Hill

INSTRUCTION ON THE USE OF THE FOLLOWING OUTLINE

The Electricity 12 course outline is divided into three columns designated: Basic Information, Operations and Projects, and References. The first column refers to the essential knowledge required. The second column outlines the activities to be performed by the students in the laboratory or shop. The third column is a guide to assist the instructor in locating the topics in the text. It is intended that this column also be used to indicate supplementary references deemed necessary to fill in topics where the text is inadequate. Instructors are requested to insert references which they consider to be most suitable for the particular topics outlined. It would be desirable if instructors would also note the time spent on the various units. In revising this outline, this will be extremely valuable to the curriculum committee. We ask that instructors keep two copies of this guide, one which can be returned to the Department with the instructor's notations as mentioned above, and one for their own records.

The time for each unit is noted and should be adhered to as closely as possible to ensure coverage of the entire course. There will be overlapping of theory into the laboratory which will increase the actual time devoted to the unit. It is estimated that on the average two hours will be required to complete each experiment. Timetables should be arranged so that this amount of time is available in a block so that the experiments may be completed and thus free the equipment for use by the next class.

Special Note To Instructors

Substitute V.O.M.'s for V.T.V.M.'s in all experiments from Zbar up to #24 where applicable.

Basic Information	Operations and Projects	References
UNIT I: OPPORTUNITIES IN ELECTRICITY AND ELECTRONICS - 4 hours (Recommended 2 hours in September and 2 hours in June)		
A. Engineers.		
B. Technicians.	Familiarization tour of the laboratory or shop to acquaint class with shop procedure and routine.	
C. Related fields.		
D. Training, employment and future.		
UNIT II: BASIC CONCEPTS OF ELECTRICITY - 20 hours		
A. Electron theory of matter.		Long, Section 1
B. Static electricity.	Duff, Exp. #1	
C. Dynamic electricity.		
D. Electromotive force.		
E. Resistance and conductance.	Duff, Exp. #6	Long, Section 2, 8
F. Insulators and conductors including aluminum.	Duff, Exp. #7 Long, Exp. #22, 23	
UNIT III: SOURCES OF E.M.F. - 4 hours		
A. Friction.		Loper, Units 15 & 16
B. Chemical action.		
C. Heat action.		Long, Section 12
D. Light action.		
E. Pressure (Piezo-Electric Effect).		
F. Mechanical.		
UNIT IV: BASIC D.C. CIRCUITS - 25 hours		
A. Basic components of a D.C. circuit.		Long, Section 4

Basic Information	Operations and Projects	References
Unit IV: Basic D.C. Circuits - Cont'd		
B. Series circuits.	Z, Exp. #10	
C. Parallel circuits.	Duff, Exp. #4 Z, Exp. #11	Long, Section 5 & 6
D. Switches - types and their application.		C.S.A. Code
E. Series - parallel circuits.	Duff, Exp. #5 Z, Exp. #12	
F. Use and care of meters.	Z, Exp. #5, 6, 7, 8	
G. Ohm's Law.	Duff, Exp. #2, 3, 8 Z, Exp. #9	
H. Energy and power.	Long, Exp. #19, 20	Long, Section 7
I. Kirchhoff's Law.	Duff, Exp. #12 Z, Exp. #13	
J. Voltage dividers.	Z, Exp. #14 & 15	
UNIT V: MAGNETISM AND ELECTROMAGNETISM - 13 hours		
A. History of magnetism.		Loper, Unit 9
B. Natural and artificial magnets.		
C. Magnetic poles.		Long, Section 11
D. Magnetic fields.		
E. Laws of attraction and repulsion.	Duff, Exp. #9a	
F. Magnetic field strength.		
G. Magnetic field around a current.	Long, Exp. #24	
H. Carrying conductor.		
I. The solenoid and electromagnet.		
J. Applications of electromagnet.	Duff, Exp. #9b	

Basic Information	Operations and Projects	References

UNIT VI: D.C. MEASURING INSTRUMENTS (Introduction) - 8 hours

A.	The D'Arsonval movement.	Z, Exp. #19
B.	The D'Arsonval as a voltmeter.	Z, Exp. #20
C.	The D'Arsonval as an Ammeter.	Z, Exp. #21
D.	V.O.M. & V.T.V.M.	
E.	Measuring resistance. 1. Voltmeter - ammeter method 2. Ohmmeter 3. Wheatstone bridge	
F.	Wattmeter and watthour meter.	

ELECTRICITY 22

Having reviewed the basic concepts taken in Electricity 12, it is intended that the Electricity 22 course content shall present a further study of basic theory and supporting experiments pertaining to electro-magnetic induction; D.C. generators, D.C. motors and control, A.C. circuit components, A.C. series and parallel circuitry.

It is intended that the student should accept the growing importance of electronics in all parts of the electrical and related fields of technology. It is deemed to be no longer possible to have an electrical course without including content of what has been termed the field of electronics.

It is also intended that about half of the laboratory time will be given to shop activities on use of tools and wiring practices.

TEXTS

	Author	Publisher
ELECTRIC CIRCUIT AND MACHINES	Eugene C. Lister	McGraw-Hill
CANADIAN ELECTRICAL CODE, Part I		C.S.A.

Students' Laboratory Experiment Manual:

BASIC ELECTRICITY	Paul B. Zbar	McGraw-Hill

The following reference lab manuals and texts should be in the library in addition to those listed for Electricity 12:

Reference Laboratory Experiment Manuals:

LABORATORY EXPERIMENTS -DIRECT CURRENT FUNDAMENTALS	John R. Duff	Delmar
LABORATORY EXPERIMENTS -ALTERNATING CURRENT FUNDAMENTALS	John R. Duff	Delmar

Reference Texts

BASIC ELECTRICITY, D.C. FUNDAMENTALS	O. Loper	Delmar
BASIC ELECTRICITY	Bernard Grob	McGraw-Hill
INDUSTRIAL ELECTRICITY, Vol. 1, D.C., 3rd Edition	C.L. Dawes	McGraw-Hill

Reference Texts Cont'd:

BASIC ELECTRICITY, Part 3	Van Valkenburgh	Technical Press
BASIC ELECTRICITY, Part 4	Van Valkenburgh	Technical Press
INTRODUCTION TO ELECTRIC CIRCUITS	Herbert Jackson	Prentice-Hall
ELECTRICAL EXPERIMENTS	Frank J. Long	General Publishing Company
EXPERIMENTAL ELECTRICITY	Rahn, Magnuson, Dooley	McGraw-Hill

GENERAL ELECTRICAL THEORY

1. Review - 20 hours

   - Review of Ohm's Law, Kirchhoff's Law, and D.C. series, parallel circuits - 15 hours.
   - Review of magnetism and electro-magnetism - 5 hours.

2. Electromagnetic Induction - 40 hours

   - Induced E.M.F.
   - Factors affecting the amount of induced E.M.F.
   - Faraday's Laws of induction.
   - Numerical value of induced E.M.F.
   - Direction of induced E.M.F.
   - Lenz's Law of induction.
   - Self-induction in a coil.
   - Mutual induction.
   - Ignition systems.

3. D.C. Generators - 50 hours

   - Basic construction (review).
   - Single coil D.C. generator (review).
   - Multicoil armatures (methods of diagraming armature windings).
   - Field excitation - types of generators.
   - Generator voltage equations.
   - Armature reaction.
   - Commutation.
   - Interpoles.
   - Motor action of a generator.
   - Voltage regulation and operating characteristics of various types of generators.
   - Efficiency.

4. D.C. Motors and Control - 30 hours

   - Motor principles and torque development in a motor.
   - Measuremet
   - Generator action of a motor.
   - Armature reaction and methods of counteracting.
   - Types of motors and their characteristics.
   - Motor starters and controls.

5. Alternating Current and Single Phase Circuits - 20 hours

   - Basic A.C. theory - cycles, frequency, period, electrical degrees, effective value, average, instantaneous values, ete.
   - Properties of electric circuits.

6. Electrical Sketching and Blueprint Reading - 10 hours

- Electrical symbols (Canadian Electrical Code).
- Lettering.
- Schematic diagrams.
- Elements of print reading.

7. Laboratory Experiments - 80 hours

Using the following laboratory experiment manuals -

A - Basic Electricity by Zbar
B - D.C. Fundamentals by John R. Duff
C - A.C. Fundamentals by John R. Duff

the following schedule of experiments is suggested:

Experiment	Manual	Job or Experiment	Topic
1			Induction, Faraday and Lenz Law
2			Mutual Induction
3			Telephone - transmitter circuit
4			Basic A.C. Generator
5			Basic D.C. Generator
6	A	29 & 30	Oscilloscope Operation
7	A	32	Characteristic of an inductance in a series LR - D.C. circuit
8	C	5	Characteristic of a capacitance in a series CR - D.C. circuit
9			Simple auto ignition system
10			Construction of details of D.C. Generator
11			Types of winding for armatures
12	B	15	Magnetization curve of separately excited D.C. Generator
13	B	16	Load curve of separately excited D.C. Generator
14	B	17	Load curve of a shunt D.C. Generator

Experiment	Manual	Job or Experiment	Topic
15	B	18	Load curve of a compound D.C. Generator
16	B	19	Connections for a compound generator
17	B	30	Efficiency of moter-generator set

Manual B is DIRECT CURRENT FUNDAMENTALS LABORATORY EXPERIMENTS - John R. Duff

C - D.C. Motor and Controls

Shop Activities (See also Experiments 25 and 26 Manual B)

Job 1 - To determine the armature resistance of a D.C. motor and demonstrate the principles of E.M.F., similar to experiment #22, Duff's D.C. Fundamentals.

Job 2 - To determine the effect of armature voltage on speed and field voltage on speed (separately excited).

Job 3 - Connect up a shunt motor:

(a) Controlled from a three-point starting box
(b) Controlled from a four-point starting box with rheostat field control
(c) Add pilot light and emergency stop to the above

Job 4 - Plot the speed-load curve for:

(a) A separately excited motor
(b) A self-excited shunt motor (similar to Duff D.C. Fundamentals manual, experiment #27)

Job 5 - Plot a speed-load curve for a series motor.

Job 6 - Static torque test of D.C. shunt motor (See experiment #23 Duff,D.C. Fundamentals).

Related Shop Theory

Branch circuit conductor size - flexible or rigid conduit - code regulations regarding the same. Over current protection-factors in the selection of motor controls and disconnect switches.

Motor rotation - grounding equipment - starting time and nature of load. Need for emergency stop station, need for pilot light, its location.

Reversing to be done in armature circuit only, series field not to be reversed. Shunt field not to be reversed. Means of speed control. Need for full-field relay, connection of rheostat and relay in motor circuit. Comparison of series motor circuit and controller to that shunt. Nature of load, and nature of connection to load. Series motor never to be without load. Other safe guards in installing series motors, manual and automatic speed limiting devices. Reversing switches rating, etc. Selection of started - types of starters.

Motor maintenance - (theory only) - bearing - lubrication, cleaning armatures, turning commutators - undercutting - testing - repainting - replacing brushes - checking spring brush tension.

SHOP ACTIVITIES AND RELATED THEORY

Summary

A. Tools - Shop Activities - Jobs 1 to 5

- Appendix 1 - Tools to be studied in the Electricity 22 course.

- Related Shop Theory - (a) Framework of study for tools and tool operations.
(b) Shop Science.

B. Low Voltage Signal Circuits - Shop Activities - Jobs 6 to 15

- Related Shop Theory - Circuit and wiring Theory.

C. Interior Residential Wiring Practices

- Nonmetallic Sheath Cable - Shop Activities - Jobs 16 to 23

- Related Shop Theory - Wiring practices, regulations, etc. pertaining to residential wiring with nonmetallic sheath cable. Note special circumstances pertaining to the use of aluminum conductors and approved fittings. (See C.S.A. Code.)

D. Interior Wiring Practices

- Electrical Metallic Tubing and Rigid Conduit - Shop Activities - Jobs 24 to 28

- Related Shop Theory - Regulations
- Fittings
- Operations

E. Other Wiring Materials as Covered in Section 12 of C.S.A. Code - Shop Activities - Jobs 29 to 20

- Related Shop Theory - Regulations
- Types
- Operations

F. Basic Tools:

Shop Activities

Job 1 - Metal Tools - Construct one or more small metal projects which will introduce the student to and teach him the skills in the use of the basic metalworking tools.

Job 1 - Cont'd

(Suggested Projects - small tool box, tap and drill gauge.)
Operations such as the following should be included:

a. Marking out - squaring stock - locating centers.

b. Center punching - drilling - countersinking.

c. Hacksawing - filing - chiseling - various methods of application.

d. Using taps and dies in threading.

e. Sharpening screwdrivers - chisels - knives - punches, etc.

Job 2 - Use of small tools of the Electrical Trade - Make up an acceptable set of sample splices in the various common conductors, e.g., 18 gauge to #8 solid and stranded - learn to use wire gauge in selecting conductors.

a. Estimating material needed for splice - amount of insulation to be removed.

b. Make use of various methods and tools for removing insulation.

c. Make use of various tupes of pliers and wire cutters as the job demands.

d. Soldering Splices - make use of several kinds of soldering iron torches.

e. Make a duplicate set of splices and re-insulate one set.

Job 3 - As an exercise, properly affix a set screw connection lug to a short length of #2 service entrance conductor.

a. Several types of terminal lugs are available using either standard of Allan type set screws.

b. Proper use of set screw pressure terminals.

c. Proper use of crimp type connectors and lugs, #14 - 2/0.

d. Proper use and application of twist on connectors or wire nuts.

Job 4 - Cut a short length of 1/2 or 3/4 inche rigid conduit using a hacksaw. The danger in using a pipe cutter should be pointed out, that is the swagging effect which reduces the size of the pipe leaving a sharp edge which requires excessive reaming to produce an acceptable job.

GENERAL TRADE SKILLS AND KNOWLEDGE

A. Basic Tools:

Related Shop Theory

1. To give greater meaning and depth to basic shop activities involving tools, related theory should accompany the activity. It is suggested that as the tools are taught, that related theory pertaining to a tool follow the outline below as it applies.

   a. Name and variety of type of the same tool.

   b. Reasons for use as demonstrated.

   c. Care of sharpening and conditioning.

   d. Other related tools and operations, e.g., woodworking tools, use and care.

   e. Relation and application to the electrical trade, e.g., cutting out for switch boxes in existing and finished walls, remove floor boards and cutting pocket for fishing and replacing without damaging wood.

   f. Safety in the handling of equipment, e.g. lifting - use of ladders, using power equipment - stud guns and explosives - first aid.

2. Shop Science

   a. Types of steel and tool application.

   b. Cutting speeds and feeds (drilling).

   c. Standard threads - machine - pipe - form and pitch, etc.

   d. The micrometer.

   e. Decimal equivalent.

   f. Sheet metal and wire gauge.

B. Low Voltage Signal Circuits:

Shop Activities

Job 6 - Install a vibrating type bell controlled by one surface type push button switch.

Job 7 - Install one vibrating bell that can be controlled from two positions by separate parallel push button switches.

Job 8 - Install two vibrating bells in parallel and controlled by one push button.

Job 9 - Install two vibrating bells each controlled by a separate push button switch.

Job 10 - Install a three wire return call system.

Job 11 - Install front and back door bell systems for a two-family dwelling including one door opener. Test circuit with continuity checkers.

Job 12 - Install and wire a multi-drop manual reset annunciator (surface) - make use of continuity tester.

Job 13 - Install a low voltage D.C. relay to control a low voltage A.C. circuit.

Job 14 - Install a two-station open circuit burglar alarm as might beused in a private dwelling or small store.

Job 15 - Install a standard two-station battery operated telephone system.

Related Shop Theory

a. Series circuits - parallel circuits, combination series parallel circuits - reading blueprints and specifications.

b. Types of low voltage switches - methods of mounting - types of bells - buzzers.

c. Terminating of conductors and precautions against short circuits, removing insulation, running and stapling of conductors to avoid damage to wires, neatness of workmanship.

d. Installation regulations for bell transformers and general precautions, circuit resistance-distance, mechanical protection of wiring, over-current protection.

e. Annunciators, burglar alarms and fire alarm systems.

f. Knowledge of building construction, fishing of conductors in old work, new work, securing conductors to backboard or stud to prevent movement or damage at time of plastering.

g. Relays - design, purpose and function - applications.

h. Continuity Testing - various methods, e.g., bell or buzzer and battery, with a bell ringer, test lamps, earphones and battery, ohmmeter, sound power telephone, their principles of operation, induction crosstalk and danger of error.

C. Nonmetallic Sheathed Cable:

Shop Activities

Job 16 - Install one light mounted on a 4" octagonal outlet box, controlled by a single pole surface type switch, using nonmetallic sheathed cable.

Job 17 - Install one unswitched light, and anohter light controlled by a single pole surface type switch, using nonmetallic sheathed cable (surface). 4" boxes to be used throughout.

Job 18 - Install one light controlled from two three-way switches.

Job 19 - Install one ceiling outlet controlled by a single pole switch, and one unswitched receptacle outlet.

Job 20 - Install two wall lighting outlets, controlled by a single pole switch, and two receptacle outlets, controlled by two three-way switches. One of the three-way switches to ganged with the single pole switch.

Job 21 - Install one lighting outlet controlled from two or more places, using a standard low-voltage remote control system.

Job 22 - Install a 60 watt recessed incandescent lamp fixutre in an existing structure.

Related Theory (Caution students regarding T.Q. Act and Local by-laws and permit requirements.)

Types of boxes, connectors, fittings, switches, cable, applications - Code requirements, use of nonmetallic sheathed cable in new buildings, grounding, testing circuits. Use in old houses, removing floor boards, removing trim, installing outlet boxes, fishing, passing obstructions, boring holes, installing special lighting fixtures, recessed fixtures, fluorescent fixtures.

D. Electrical Metallic Tubing and Rigid Conduit:

Shop Activities

Job 24 - Install a circuit of unswitched lighting in a surface run of 1/2 inch conduit.

Job 25 - Install in a surface run of 1/2 inch conduit having one 90 degree bend, a circuit of one light controlled by a single pole switch.

Job 26 - Install in a surface run of 1/2 inch conduit a circuit of one light controlled by a single pole switch, and one unswitched convenience outlet.

Job 27 - Install two lights controlled by two three-way switches.

Job 28 - Install a circuit in 1/2 inch EMT to specifications a circuit of one light controlled by two three-way switches and one four-way switch.

Related Theory

a. Information regarding the use of the various EMT fittings, connections, couplings, elbows, clamps, etc.
   - Method of cutting, reaming, threading, bending.

b. What the code sets down regarding conductor sizes and number of conductors allowed in various sizes of conduit, bending radius. Reading specifications, fishing and pulling wires, tapes.

c. Use of levels, plumb bobs, chalk lines, etc.

d. Anchoring devices - toggle bolts, rawl plugs, expansion sleeves, etc.

E. Other Wiring Material:

Shop Activities

Job 29 - Make up a bill of material from a drawing or blueprint referring to suppliers catalogues.

Related Theory

Associated with other wiring materials as outlined in Section 12 of C.S.A. Code.

Code:

Studies in the following sections of the Canadian Electrical Code, Part I, latest edition.

Section 0 - Definitions
Section 2 - General rules
Section 4 - Conductors
Section 6 - Services
Section 12 - Wiring methods
Section 16 - Remote control (Introduction)
Section 30 - Installation of interior lighting to rule 30-086.

Apprendix I - Tools to be studied in the Electricity 22 Course

1. Wire gauges.
2. Micrometers.
3. Hand drills - manual and power - and twist drills and bits.
4. Taps and dies.
5. Cold chisels.
6. Hammers.
7. Hacksaws.
8. Files.
9. Grinders.
10. Wheatstones.
11. Screwdrivers.
12. Wrenches.
13. Pliers and wire cutters.
14. Chalkline - plumb bob.
15. Concrete drills.
16. Bell hangers drills.
17. Pipe cutters.
18. Pipe reamers.
19. Wire strippers.
20. Crimping tools.
21. Indenting tools.
22. Soldering irons and torches.
23. Knockout cutters and chassis punches.

24. Pipe benders.

25. Fish tapes.

26. Ladders and scaffolds.

27. Safety belts.

28. Rubber matts.

29. Sleeves.

30. Gloves.

31. Explosive actuated tools.

32. Handsaw.

33. Compass saw.

34. Wood chisels.

35. Wood bits.

36. Ratchet brace.

37. Angle brace.

38. Claw hammer.

39. Steel square.

ELECTRICITY 32

(15 or 20 credits)

Texts	Authors	Publishers
ELECTRIC CIRCUITS AND MACHINES	Eugene Lister	McGraw-Hill

Canadian Electrical Code - Latest Edition

Laboratory Experiment Manuals

BASIC ELECTRICITY	Paul B. Zbar	Mc-Graw-Hill
BASIC ELECTRONICS	Paul B. Zbar	McGraw-Hill

Additional Electricity Reference Books

It is recommended that these publications be available as additional reference material.

A.C. FUNDAMENTALS	J.R. Duff	Delmar
BASIC ELECTRONICS	B. Grob	McGraw-Hill
BASIC ELECTRICITY, Part 4 and 5	Van Valkenburgh	Technical Press
BASIC MATHEMATICS FOR ELECTRONICS	Cooke	McGraw-Hill
BASIC ELECTRICAL PRINCIPLES	Suffern	McGraw-Hill
ELECTRIC MOTOR CONTROL	Alerich	Delmar
INSTRUCTOR'S GUIDE FOR ELECTRIC MOTOR CONTROL	Alerich	
ELECTRICAL DRAFTING AND DESIGN	Bishop	McGraw-Hill
ELECTRONICS IN INDUSTRY	Chute	McGraw-Hill
ELECTRICAL CONTROL SYSTEMS IN INDUSTRY	Siskind	McGraw-Hill
ELECTRICAL EXPERIMENTS	Frank J. Long	General Publishing
FUNDAMENTALS OF ELECTRICITY	Graham	American Technical Society
INTERIOR ELECTRIC WIRING (RESIDENTIAL)	Graham	American Technical Society

Electricity Reference Books - Cont'd

INTERIOR ELECTRIC WIRING (INDUSTRIAL)	Graham	American Technical Society
ELECTRIC MOTOR REPAIR	Rosenberg	Holt, Rinehart and Winston
WESTINGHOUSE LIGHTING HANDBOOK		A4064 - Westinghouse Lamp Division of Westinghouse Electric Corp., Bloomington, New Jersey
ELECTRICAL TRADES - BLUEPRINT READING AND SKETCHING (RESIDENTIAL)	Mullin	Thomas Nelson and Sons Limited
ELECTRICAL TRADES - BLUEPRINT READING AND SKETCHING (COMMERCIAL)	Fisher and Arendt	Thomas Nelson and Sons Limited

It is intended that this course shall be an introduction to the basic electrical equipment of industry. Advanced courses at the Technical Institutes and University will provide for detailed study of construction, industrial control, application and testing of this and related equipment.

GENERAL ELECTRICAL THEORY - 210-275 hours

1. Electrical Sketching and Blueprint Reading - 10 hours

   - Pictorial drawing.
   - Dimensioning.
   - Mechanical plans of electrical apparatus.

2. Alternating Current and Single Phase Circuits - 60 hours

   - Basic A.C. Theory - cycles, frequency, period, electrical degrees, effective value, average, instantaneous values, etc.
   - Properties of electric circuits.
   - Resistance, inductance, capacitance.
   - Inductive reactance, capacitive reactance.
   - Series and parallel circuits involving inductance, and capacitance.
   - Impedance.
   - A.C. measuring instruments.
   - Power in A.C. circuits, power factor.
   - Series and parallel circuits involving resistance, inductance and capacitance.
   - Series and parallel resonance.

3. A.C. Measuring Instruments - 5 hours

   - Voltmeter, ammeter, single phase wattmeter, electrodynamometer, frequency meter, kilowatt-hour meters.

4. A.C. Generators - 20-30 hours

   - Basic construction - single phase, etc.
   - Principles of generator operations.
   - Regulation.
   - Paralleling and synchronizing (Introduction of basic theory only).
   - Ratings.
   - Loss and efficiency.
   - Introduction to polyphase generation.

5. A.C. Motors and Controls (single phase) - 30-40 hours

   - Rotating fields.
   - Squirrel cage rotors.
   - Wound rotors.

5. - Torque.
   - Speed.
   - Starting conditions.
   - Types of A.C. motors, single phase, split phase, capacitor start, capacitor run, universal motors, shaded pole motors, etc.

6. Transformers - 10-15 hours

   - Basic principles and construction.
   - Types of transformers - instrument, potential, current, auto transformers, isolation, etc.
   - Operation - no load, load.
   - Connections - single phase.

7. Electronics - 70-80 hours

   (a) Vacuum Tubes and Application

   1. Vacuum tube theory.
   2. Diode vacuum tube and characteristics.
   3. Triode vacuum tube and characteristics.
   4. Tetrode vacuum tube and characteristics.
   5. Pentrode vacuum tube and characteristics.
   6. Power supplies.
   7. Triode vacuum tube characteristics curves, parameters, and gain.
   8. Triode grid, its control and application of a triode in control circuitry.
   9. Load line and cut-off point.
   10. Use of the Q point and the load line.
   11. Load resistor, grid leak resistor, input and output.
   12. Self biased amplifier.
   13. Voltage and power amplifier and application.
   14. Coupling of amplifiers.
   15. Classes of amplifiers and application.
   16. Push-pull amplifier and its application.
   17. Voltage doubler.
   18. Voltage regulator tube-gas type.
   19. Oscillators.
   20. Diodes, special diodes (Zener).

   (b) Semi-conductors and Application

   1. Semi-conductor theory.
   2. Germanium crystal lattice.
   3. N and P impurities in germanium crystal lattice.
   4. Diode characteristics.
   5. Transistors, PNP and NPN and current flow.

6. Transistor amplifier circuitry fundamentals.
7. Transistor amplifier biasing.
8. Transistor amplifier configurations and applications.
   (i) Common Emitter (CE)
   (ii) Common Base (CB)
   (iii) Common Collector (CC)
9. Transistor current flow.
10. Introduction to S.C.R.

8. Lighting - 5 hours

- An introduction to lighting.

FXPERIMENTS, SHOP ACTIVITIES AND RELATED THEORY

SUMMARY

A. Services - Shop Activities - Jobs 1 and 2.

Related Shop Theory - Code Extracts.

B. Experiments - 1 to 18.

C. A.C. Generator Experiments - Experiments 19 and 20.

D. Single Phase A.C. Motors - Shop Activities - Jobs 3 to 8.

Related Shop Theory - Connections and considerations with respect to suitability for a job.

E. Transformers - Experiments 21 to 24.

F. Vacuum Tubes, Rectifiers and Power Supplies - Experiment 25 to 31.

G. Transistors - Experiments 32 to 40.

H. Lighting - Experiments 41 and 42.

I. Heating controls - Shop Activities - Jobs 9 to 15.

Related Shop Theory - Theory of heating controls and combustion safety requirements.

A. Services:-

Shop Activities

Job 1 - Install 100 amp., 3 wire, single phase service using main breaker, range breaker and four S. P. breakers. Wire with service conduit and locate meter outside.

Job 2 - In a building mock-up using conduit, install a single phase service, feeding two combination service boxes each containing main range and four branch circuits. Meters to be in a trough inside the building. Provide grounding.

Related Shop Theory - Pertinent Code Extracts, including E.P.A. regulations on interior and farm wiring.

B. Experiments:

CODE REFERENCE FOR LABORATORY MANUALS

A - Basic Electricity by Paul B. Zbar (3rd Edition)

C - Laboratory Experiments by John R. Duff
Alternating Current Fundamentals

DD- Basic Electronics by Paul B. Zbar (3rd Edition)

Experiment	Manual	Job or Experiment	Topic
1	A	32	Characteristic of an inductance in series LR circuit - A.C. circuit.
	C	1	
2	A	33	Inductances in series and parallel.
3	C	2	Power Factor in inductive A.C. circuit.
4	C	3	Effective resistance.
5	C	4	Effect of frequency on inductive reactance.
6	C	6	A.C. capacitance circuit.
	A	36	
7	C	7	Effect of frequency on capacitive resistance
8	A	37	Capacitors in series and parallel.
	A	41	

Experiment	Manual	Job or Experiment	Topic
9	A	34	Capacitor color code and testing capacitors.
10	C	8	A.C. series LCR circuit.
11	C	9	A.C. Parallel circuit with R and X_L branches.
12	C A	10 43	A.C. Parallel circuit with R, X_L, X_C branches.
13	A	44	Characteristics of Series Resonant circuit.
14	A	47	Characteristics of a Parallel Resonant circuit.
15			Basic Transformer Construction.
16	A	48	Transformer Characteristics.
17	C	21	Transformer Ratio and Polarity Testing.
18	A	29	Oscilloscope Voltage Calibration.

C. A. C. Generator Experiments:

Experiment	Manual	Job or Experiment	Topic
19	C	17	Alternator Impedance (Single Phase) (Optional)
20	C	18	Voltage Regulation of Alternators

Manual C is Alternating Current Fundamentals - Laboratory Experiments, John R. Duff.

D. Single Phase A.C. Motors:: (See also Experiments 35 and 36 - Manual C)

Shop Activities

Job 3 - Hook up a split-phase motor controlled by a suitable motor control switch.

Job 4 - Connect a single phase capacitor motor, using a reversing switch.

Job 5 - Hook up a single phase capacitor start motor controlled with a thermal overload switch.

Job 6 - Hook up a 115 volt capacitor motor, to be remotely controlled from one push button control station.

Job 7 - Study the operation and hook up a 115 volt universal motor.

Job 8 - Study the operation and hook up a shaded pole motor.

Related Shop Theory - Selection of suitable motors for particular jobs. Advantages and disadvantages. Supply circuits, motor ratings, selection of controls. Direction of rotation, bearings, lubrication, use of reversing switches, thermal switches, overcurrent protection.

E. Transformers - Laboratory Experiments

Experiment	Manual	Job or Experiment	Topic
21	-	-	Construction of transformers and report (3 to 5KVA).
22	C	21	Transformer Ratio and Polarity (Using 1KVA Transformers).
23	C	25	Single Phase, Three wire system.
24	C	26	Single Phase, Transformers in Parallel.

For Experiments 22 to 24 use IKVA Transformers.

F. Vacuum Tubes, Rectifiers & Power Supplies

Experiment	Manual	Job or Experiment	Topic
25	-	-	Examination of construction of used Vacuum Tubes Diode, Triode, Tetrode, Pentode.
26	D	5	Vacuum Tube - Diode Characteristics.
27	D	8	The Diode Rectifier.
28	D	16	Triode Characteristics.
29	D	17	Triode as a D.C. Amplifier.
30	D	20	Triode as an A.C. Amplifier.
31.	D	9	Filter Circuits.

G. Transistors

Experiment	Manual	Job or Experiment	Topic
32	D	13	Transistor Familiarization.
33	D	14	Current Gain in Transistors.
34	D	15	Transistor Characteristic curves and Transistor Data.
35	D	23	Common-emitter amplifier.
36	D	24	Common-base amplifier.
37	D	27	Cascaded transistor amplifier.
38	D	33	Frequency response of an audio amplifier.
39	D	31	Transistor phase inverter.
40.	D	37	The Hartley Oscillator.
41.	D	42	S.C.R.

Manual D is Basic Electronics, Zbar (3rd Edition).

H. Lighting

Experiment	Manual	Job or Experiment	Topic
42	-	-	Examination of Component Parts of Flourescent lamps, ballasts and Starters.
43	-	-	Circuitry for single and dual lamp ballasts and fixture complete.

I. Heating Controls

Job 9 - Connect up and test the heating controls for a gas fired, gravity furnace system on propane.

Job 10 - Connect up and test the heating controls for a forced warm air natural gas fired furnace.

Job 11 - Connect up and test a two zone, single furnace warm air system.

Job 12 - Connect up and test a two position valve and a modulating valve - on respective thermostats.

Job 13 - Connect up and test a domestic water pressure system.

Job 14 - Connect up and test a power type oil burner and controls.

Job 15 - Connect up and test the combusion controls for a commercial steam or hot water heating boiler, natural gas fired.

These seven heating control jobs will be done using "breadboard" assemblies of typical controls, arranged to operate in principle as on a regular installation.

Related Shop Theory - Provide a background of combustion and control operation theory, and the regulations and code requirements for this type of installation.

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